The Human-Machine Factor

By LCdr. Jeff Alton

Human factors, which figure into more than 80 percent of our aviation mishaps, are more complex than most people realize. In the Navy, we refer to human factors as variables in someone's personal life that may affect mission performance: nutrition, stability of relationships, fatigue, finances, and so on. Outside the military, however, human factors are viewed on a larger scale: the science of evaluating the human-machine interface.

Too often, engineers design systems and expect the human to be trained to use them. Human-factor designers want to change this relationship. They seek to measure the limitations of human performance and design systems to fit within those limitations. The objective is to aid the human and enhance performance. They try to design systems to fit the people, rather than train the people to fit the system.

While gear-up situations rarely occur now because of better engineering, military and civil databases are full of such instances, which contributed to development of the human-factors field. In the latter days of World War II, when the Army Air Corps pushed as many pilots through the pilot pipeline as possible, they noted several incidents where pilots retracted the landing gear while on the runway after landing. Because of so many incidents, they tasked a psychologist to find the root of the problem. He found these occurrences were more prevalent when pilots transitioned from one airframe to another. This action led to what is known in the human-factors field as negative-habit transfer, or more commonly known as force-of-habit. This behavior happens when a well-learned and practiced behavior is applied in the correct situation but on an incorrect control.

Consider when you drive a rental car and turn on the wipers instead of the lights, because the controls are different from your car. When pilots transitioned from one airframe to another, they found some of the controls were in different places. This situation contributed to most of these mishaps (e.g., the controls for the flaps and the landing gear were reversed). Back then, aeronautical engineers designed aircraft, often without regard to what helped the pilots do their jobs or what designs were most logical, based on the job at hand. Aircraft were designed in a way that was engineer-driven. Gauges and controls were placed where the engineers could run the least amount of cable to save weight and for ease of manufacture. The result was a hodgepodge of instruments and controls, with no real logical arrangement, which allowed aircraft from different manufacturers to have different placements of gauges and reversed controls.

A human-factors engineer can mitigate such a situation in several ways. An engineer could, without excessive modification, change the shape or actuation of the particular control. This modification can be seen in most later-model aircraft. For example, the shape of the flap handle is a long, flat switch that is oriented horizontally to replicate the shape of the actual system.

A human-factor problem:

You've had another great flight, topped off with a picture-perfect three-point landing. After rollout, you retract the flaps per the post-landing checklist, only to find that the landing gear inexplicably retracted instead. There's nothing wrong with the plane; you've just grabbed the gear handle and have become a member of the no-so-exclusive gear-up club, comprised of members who either have inadvertently landed with the wheels retracted, or accidentally retracted them while on the ground.

The handle for the landing gear in most aircraft looks like a wheel and is oriented vertically to represent the orientation of the wheel with reference to the airframe. This design allows the pilot to tell which control he or she is grabbing, simply by feel.

Many landing-gear controls also have an interlock, which requires the pilot to pull the handle out before raising or lowering, or to include a thumb lock that must be actuated for the gear handle to move. In most cases, the flap handle can be raised with no such additional action. This solution requires little money and reengineering.

The cheapest of all solutions is to change the procedure under which the control is operated. This action can be done by adding to or modifying a checklist. These extra steps provide additional opportunity to verify the control before activation. In a multi-crew aircraft, responsibilities could be divided so that one pilot always operates the flaps, and the other operates the landing gear.

The best way to remedy the problem—also the most expensive and difficult—is to standardize the controls and displays so that transition from one platform to another would incur minimal training. However, this fix is expensive because it would require manufacturers to rework their tools and jigs to fit the accepted standard. This fix also is difficult because no manufacturer wants to redesign a product to fit that of a rival company.

Most designs now have conformed to an arrangement of gauges known as the “basic T,” which places basic-flight instruments to yield the most efficient scan pattern. In this arrangement, the attitude indicator (AI) is in the center at the top of the instrument panel, as it is the most important and should be sampled most frequently. To the right of the AI is the altimeter, and to the left of the AI is the airspeed indicator. Below the AI is the directional gyro. This arrangement allows the pilot to minimize eye movements when viewing all gauges and returning to scan the AI.

The information presented by this arrangement has been replicated on the HUDs of more advanced aircraft, with the possible exception that depending on the type of HUD or the phase of flight, heading information may be above the attitude information. Whether it is a basic or inverted basic T, this placement has become the accepted standard for presentation of basic flight information.

I can hear the T-34C drivers saying, “Wait a minute, our panel looks nothing like that.” The reason is that the T-34 is late 1940s technology and was produced before any serious attention was given to efficient gauge arrangement or logical control placement. I am not denigrating the engineers at Beechcraft nor the venerable T-34, which has trained thousands of aviators. I have a great affinity for Beechcraft products, and most of my private flying time is in a Beech model.

The replacement for the T-34C is another Beechcraft model: the T-6A Texan II. While I have not flown in one, I hear from my Air Force colleagues it is an incredible thrill ride and is more sophisticated than many of our fleet aircraft. It has a glass-cockpit and faithfully has replicated the basic-T flight information on electronic displays. As the T-6 is a significant leap forward with regard to human-factors issues, we look forward to it launching the flying careers of thousands more aviators over the next few decades.

One footnote to the gear-up issue is, while it is no longer common, it still happens. Recently, we conducted a safety survey of a training squadron and found they had experienced some pilots who also had tried to raise the gear while on the ground. They apparently solved their problem procedurally, and it seems to have worked for now. My guess (and that’s all it is, as we didn’t have time to fully explore the issue) is that a contributing factor was a right seat-left seat transition. You folks know who you are; I’d like to hear from you, as that might make a great human-factors case study.

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ORM Corner

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